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AN EXPERIMENTAL TEST OF THE LAW OF ASSIMILATION

A DISSERTATION SUBMITTED TO THE
GRADUATE FACULTY IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

By
KWANG SUP YUM

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BY K. S. YUM

University of Chicago

This investigation is concerned with the following problem: To what extent will a motor response that has been contiguously associated with a given perceptual stimulus be aroused by a similar stimulus with which it has not been associated, and to what extent is the likelihood of arousal a function of the degree and kind of similarity involved?

This problem is never encountered in the early literature of association. Some of the modern writers have assumed the truth of the doctrine, and a few have classified the phenomenon under a separate law of association as the Law of Assimilation¹ by Carr (10), Response by Analogy by Woodworth (66), and the Law of Redintegration by Hollingworth (27.) On the other hand a few like Spencer (1, 54, 59), Bain (1, 59), Ward (58), and Peters (47) have attempted to explain the phenomenon in terms of the conventional Law of Similarity. This law states that the thought of an object tends to arouse the thought of a similar object. In other words, an object makes you think of similar objects that you have known. Here, the similarity involved is between the stimulus and response items. Obviously the law is applicable only to ideational sequences and not to perceptual-motor connections. To account for the fact that a new perceptual object will call out a motor response associated with a similar perceptual stimulus on the basis of this law, they assumed that the new perceptual object first aroused an image or idea of the similar object, and that this image then evoked the motor response in accordance with the Law of Contiguity. In the first connection between the

¹The term 'Assimilation' was used by Ward (58), Spencer (54), and Drobisch (18), but they meant by the term a particular process of 'blending or fusion' of a presentational continuum—a similarity that amounts to identity only.

new stimulating object and the image or idea of the similar object, the stimulus and response items are similar, and hence this part of the associative sequence is to be classified under the conventional Law of Similarity. Among these writers, the doctrine has been based upon general observation and its truth has never been experimentally tested in a systematic fashion.

Much the same condition is found in the allied field of conditioning responses. We have at present a very considerable amount of experimental work² to determine the conditions under which a response will be called out by a substitute stimulus. These experiments in the main, however, have employed the method of contiguous or simultaneous presentation of the two or more stimulating objects. Watson (60) has made a few observations on an infant relevant to the principle of similarity. He first conditioned a fear response to a white rat on the basis of simultaneous presentation, and then made a few tests to discover whether or not this fear response would also be transferred to other objects. He found that the fear response was elicited by a rabbit, to some extent by a dog and a fur coat, slightly by cotton wool, hair of the human head, and a Santa Claus mask, and not at all by the room, the table, and the infant's blocks. He, however, has not discussed in his account the differentiating principle involved, which is presumably that of similarity of the stimulating objects.

The Law of Assimilation is also encountered in the discussions of the development of language, the formation of class concepts, and the process of generalization. Writers frequently comment upon the fact that the naming responses in young children are often elicited by and attached to novel objects on the basis of their apparent similarity to objects with which they are familiar, as when they persist in calling all men 'papa,' or refer to a squirrel as 'Kitty' when it is first seen. Such illustrations are likely to convey the impression that this type of reaction is a relatively infrequent phenomenon—occurring only in these mistaken identifica-

² See 11, 12, 13, 42, 60, and others.

tions. Other writers, however, have noted that this transference of the naming responses from familiar to unfamiliar objects on the basis of their similarity occurs automatically all the time, and that this process is of fundamental importance in the development of language and of class concepts. Still other writers have insisted that this process of transference is not limited to the naming responses, but that it is a universal phenomenon applicable to all types of responses. They have also urged that this transference of responses from familiar to novel objects and situations on the basis of similarity which occurs on an automatic and unreflective level with children constitutes the germinal prototype of the process of rational generalization. For example, this general point of view has been explicitly developed by Carr (10). The transference of responses on the basis of similarity has also been recognized as a principle involved in scientific generalization—a fact that is attested by the well-known canon of inductive logic that states that what is true of one situation is also true for all similar situations. While there has been considerable experimental work done in the field of generalization and the formation of class concepts (Moore (40), Fisher (22), Hull (28), Peterson (48), Campion (9), Gengerelli (24), Shaffer (53), Eljasch (19), Hüper (30), and Lohbauer (39)), yet the principle of similarity has been taken for granted and has never been experimentally verified in a systematic way.

This transference of a response from a given stimulating object or situation to a similar stimulus obviously belongs to the general field of transfer. If the doctrine were true, similarity of the stimulating situations would constitute at least one of the conditions under which transfer occurs. Is such similarity one of the conditions of transfer? In spite of the wealth of experimental work on transfer,³ we know practically nothing as to the exact conditions under which transfer does or does not take place, the conditions under which it is positive or negative, and the factors that determine

³ Some of the recent articles and a few of the earlier ones of importance are included in the Bibliographical Section (3-8, 14-17, 20, 23, 25, 26, 29, 31-35, 37, 38, 41, 46, 49, 50, 55-57, 61-65).

the amount of transfer. We have a number of theories that purport to state the nature of these conditions, but only one of these employs the concept of similarity—that of Thorndike (55, 57) and Poffenberger (49). But in this theory, the similarity involved is that of bonds of connection, or similarity of the two activities in respect to their stimulus-response constituents, rather than a similarity of the two stimulating situations. Is similarity of the two stimulating situations a favorable or an essential condition of transfer? No one has proposed such a conception, and I know of but two experiments that have attacked the problem from this standpoint—that of Wylie (67) with animal subjects, and that of Bruce (8), an unpublished thesis in the field of memory.

The factual character of the doctrine that responses and attitudes that have been attached to given stimuli are likely to be elicited by similar stimuli with which they have not been so associated in times past, is also involved in the problem of trade mark infringements. Obviously business firms attempt infringement of successful trade marks on the assumption that the public attitudes and responses to these distinctive trade marks will likely be elicited by highly similar ones (Barber (2), Paynter (43-45), and Rogers (51, 52)). Judicial practice, however, seems to hold that an infringement is involved only when the two trade marks are so highly similar as not to be distinguished in ordinary experience. Consequently the various experiments in this field have been primarily concerned with testing the likelihood of memory confusion of a pair of such stimuli (Katzaroff (36), Feingold (21), Paynter (44, 45)), and have not attempted a systematic investigation of the more general principle involved.

The principle at issue is thus involved in such phenomena as association, conditioning, the growth of language ability, the formation of class concepts, generalization, transfer of training, and trade mark infringement. The principle is frequently not even recognized, and when recognized its truth is generally taken for granted. In only a few cases has the principle been subjected to an experimental investigation.

This experiment was initiated on the belief that a principle of such widespread and fundamental importance from the standpoint of the integration and organization of behavior should be experimentally established and systematically investigated. In our procedure the subjects are required to memorize a series of paired associates to the point of mastery. In the recall test, twenty-four hours later, novel stimuli exhibiting certain specified kinds and degrees of similarity, were substituted for the original stimuli. The amount of recall for the substitute stimuli was compared with that for the standard condition in which the original stimuli were employed.

The influence of three kinds of similarity was investigated:

1. Similarity of nonsense syllables in respect to spelling.
2. Similarity of word stimuli in respect to meaning.
3. Similarity of visual patterns.

EXPERIMENT I

Similarity of Nonsense Syllables in Respect to Spelling

The memory materials consisted of seven lists, each containing fourteen paired associates. The stimulus items consisted of two hyphenated nonsense syllables, and the response item was a word of four letters. Each pair was presented for four seconds. All the subjects memorized each of the seven lists and in the same order. Each list was learned in a single sitting, and recall was tested the following day preceding the memorization of the subsequent list. Each list was mastered to the point of a successful immediate recall with a chance order of presentation. All subjects were given one practice list before beginning the experiment proper.

The nature of the stimulus alterations employed in the subsequent recall test are specified and illustrated in Table I. Both the number and the position of the spelling alterations were varied. Each of the seven conditions of recall occurred twice in each list of fourteen paired associates, and the ordinal position of each of these seven conditions was systematically varied from list to list so that each condition occupied every ordinal position.

Records were obtained from thirty-seven subjects. Since each condition occurred twice in each of the seven lists, we obtained from each subject fourteen recall scores, and hence

TABLE I

Conditions	Original Stimuli	Response Words	Recall Stimuli
Same Syllables.....	REB-QIM	Wolf	REB-QIM
1st Letter of 1st Syllable Changed.....	HUD-LEP	Fist	XUD-LEP
2d Letter of 1st Syllable Changed.....	TOQ-BEX	Jury	TIQ-BEX
1st and 2d Letters of First Syllable Changed.....	KAJ-ZOY	View	NEJ-ZOY
1st Letter of 2d Syllable Changed.....	VAH-MIZ	Nose	VAH-PIZ
2d Letter of 2d Syllable Changed.....	WUL-GIC	Vase	WUL-GOC
1st and 2d Letters of Second Syllable Changed.....	JEC-POR	Mask	JEC-NAR

the average group value for each of the seven conditions is based upon 518 scores. The data are given in Table II. The first column lists the seven conditions. The second column gives the average number of response words recalled per individual for the seven lists—the maximum possible

TABLE II

Conditions	Average No. Recalled	Prob. Err. of Mean	Percentage Recalled
Same Syllables (Control).....	9.4865	.2992	67.761
1st Letter of 1st Syllable Changed.....	5.6216	.2325	40.154
2d Letter of 1st Syllable Changed.....	8.3784	.2085	59.846
1st and 2d Letters of First Syllable Changed...	5.5135	.3003	39.382
1st Letter of 2d Syllable Changed.....	5.7297	.2760	40.926
2d Letter of 2d Syllable Changed.....	7.5405	.2241	53.861
1st and 2d Letters of Second Syllable Changed.	5.2703	.2414	37.645

value being fourteen. The probable error of these means is also given, and finally the amount recalled is stated in percentage terms.

1. All alterations of the stimulus reduced the amount recalled as compared with the standard condition of no change. All of the differences are statistically significant.

2. An alteration of the first letter of either of the two syllables of the stimulus item reduces the recall more than does a change of the middle or vowel letters of these two syllables. Both differences are statistically significant.

3. A change of two letters in either of the two syllables

reduces the recall score more than does a change in either of the two letters singly. The differences are consistent but they are too small to permit a confident conclusion.

Stated in terms of similarity we may conclude:

1. A substitute stimulus exhibiting a similarity to the original stimulus in respect to four of the six letters elicited a large amount of recall, but an amount that is significantly less than for the standard condition.

2. There is no conclusive evidence that the amount of recall varies significantly with the degree of similarity.

3. The amount of recall varied significantly with the locus of similarity in spelling. Similarity in respect to the initial letter of either syllable is more conducive to recall than a similarity in respect to the middle or vowel components of the two syllables.

EXPERIMENT II

Similarity of Word Stimuli in Respect to Meaning

The memory material consisted of three lists—each containing twelve paired associates. Both stimulus and response items consisted of meaningful words, the response item being a word of six letters. Each pair was presented for three seconds. All the subjects memorized each of the three lists, and in the same order. Each list was learned in a single sitting, and recall was tested on the following day preceding the memorization of the subsequent list. Each list was mastered to the point of a successful immediate recall with a chance order of presentation. All subjects were given one practice list before beginning the experiment proper.

In the subsequent recall, twenty-four hours later, three conditions were employed. In one condition the original stimulus word was retained as a norm for comparison. In the other two conditions, new words were substituted for the stimulus words, and these new words exhibited one of two degrees of meaning similarity to the original stimulus words.

The procedure of selecting these similar words was as follows: For each stimulus word of the lists, the experimenter assembled a series of words exhibiting a wide range of similarity in respect to meaning. These words were then ranked

by twenty judges in respect to their degree of similarity to the original stimulus words. From each series the experimenter selected for the recall test those words which exhibited two degrees of similarity according to the unanimous opinion of the judges.

Samples of the original stimulus words, the two similar words, and the response words are given in Table III. The

TABLE III
THE STIMULUS WORDS USED IN RECALL TEST ARE ITALICIZED

Original Stimulus Words	Degree of Similarity		Response Words
	1st Degree	2d Degree	
SNAKE	<i>SERPENT</i>	TURTLE	WEALTH
<i>FIGHT</i>	BATTLE	ARGUMENT	LEDGER
HOUSE	COTTAGE	<i>BARN</i>	BREEZE

words that were employed as stimuli in the subsequent recall test are italicized. Each of the three conditions of recall occurred four times in each list of twelve paired associates, and the ordinal position of each of these three conditions was systematically varied from list to list so that each condition occupied every ordinal position.

Records were obtained from fifty-four subjects. Since each condition occurred four times in each of the three lists, we obtained from each subject twelve recall scores, and hence the average group value for each of the three conditions is based on 648 scores. The data are given in Table IV. The

TABLE IV

Conditions	Arithmetic Mean	Prob. Err. of Mean	Percentage Recalled
Same Word (Control).....	6.0185	.2167	50.154
1st Degree of Similarity.....	3.9074	.2165	32.562
2d Degree of Similarity.....	1.3519	.1640	11.266

first column lists the three conditions. The second column gives the average number of response words recalled per individual for the three lists—the maximum possible value

being twelve. The probable errors for these means are also given, and finally the amount recalled is stated in percentage terms. The differences between the means are thoroughly reliable, and the mean values for the individual subjects exhibit the same trend with but three inversions of order in the one hundred and eight comparisons.

The results prove quite conclusively that a response associated with a stimulus word tends to be aroused by a novel word having a similar meaning, and that the likelihood of arousal varies directly with the degree of similarity.

EXPERIMENT III

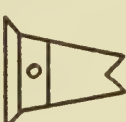
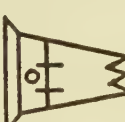
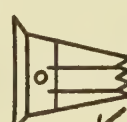
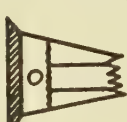
Similarity of Visual Patterns

The memory material consisted of three lists—each containing fifteen pairs of items. Each pair consisted of a visual pattern as the stimulus and a word of three letters as the response item, and it was presented for three seconds. All the subjects memorized each of the three lists, and in the same order. Each list was learned in a single sitting, and recall was tested on the following day preceding the memorization of the subsequent list. Each list was mastered to the point of a successful immediate recall with a chance order of presentation. All subjects were given one practice list before beginning the experiment proper.

Five conditions of recall were employed in the subsequent test, twenty-four hours later. In the first condition the original visual pattern was retained as a norm for comparison. In the other four conditions, new visual patterns were substituted for the original stimuli, and they exhibited one of four degrees of similarity to those stimuli. The visual patterns employed as stimuli were drawn by the experimenter, and for each of the original stimuli were drawn a series of patterns exhibiting a wide range of similarity of appearance. Each series of patterns was arranged in order of similarity by each of fifteen judges, and from each series were selected for the recall test four patterns exhibiting four gradations of similarity according to the unanimous opinion of the judges.

Samples of the patterns exhibiting all four gradations of similarity are given in Table V. Those patterns used in the

TABLE V
THE STIMULI USED IN RECALL TEST ARE CHECKED

ORIGINAL STIMULI	DEGREE OF SIMILARITY			
	1ST. DEGREE	2ND. DEGREE	3RD. DEGREE	4TH. DEGREE
				
				
				
				
				

recall test are checked. Each of the five conditions of recall occurred three times in each list of fifteen paired associates, and the ordinal position of each of these five conditions was systematically varied from list to list.

Records were obtained from twenty-six subjects. Since each condition occurred three times in each of the three lists, we obtained from each subject nine recall scores, and hence the average group value for each of the five conditions is based upon 234 scores. The data are given in Table VI.

The first column lists the five conditions. The second column gives the average number of response words recalled per individual for the three lists—the maximum possible value being nine. The probable errors for these means are

TABLE VI

Conditions	Average No. Recalled	Prob. Err. of Mean	Percentage Recalled
Same Pattern (Control).....	7.6154	.1684	84.616
First Degree of Similarity.....	5.8077	.2349	64.530
Second Degree of Similarity.....	4.4231	.2144	49.146
Third Degree of Similarity.....	4.0769	.2229	45.299
Fourth Degree of Similarity.....	3.2692	.2218	36.324

also given, and finally the amount recalled is stated in percentage terms.

The average amount recalled varies directly with the degree of similarity without a single exception. The difference between the normal condition and the first degree of similarity is statistically reliable, and the averages for all of the subjects conform to the group results. The difference between the first and the second degree of similarity is also reliable and only three of the individual means fail to conform to the average results for the group. The difference between the second and the third degree of similarity is not statistically reliable, and the same order of difference is exhibited by ten of the twenty-six subjects, and the reverse order by four subjects of the group. The difference between the third and the fourth degree of similarity does not exhibit any high degree of reliability, but the same order of difference is exhibited by sixteen subjects and the reverse order by but two subjects of the group of twenty-six individuals.

We may thus conclude that responses associated with a visual pattern tend to be aroused by a similar visual pattern, and that the likelihood of recall tends to vary directly with the degree of similarity.

CONCLUSIONS

1. Our experiment has established the fact that a naming response that is contiguously associated with a visual stimulus

is likely to be aroused by a visual stimulus with which it has not been so associated, whenever the two stimuli exhibit certain kinds and degrees of similarity.

2. The effectiveness of three kinds of similarity has been demonstrated—similarity of nonsense syllables in respect to spelling, similarity of word stimuli in respect to meaning, and similarity of visual patterns. There are no data on the relative effectiveness of these three kinds of similarity.

3. With similarities of meaning and visual patterns, the likelihood of recall varied directly with the degree of similarity. There was no evidence that the likelihood of recall varies with the amount of similarity of nonsense syllables as measured by the number of letters in common.

4. With nonsense syllables employed as stimuli, the likelihood of recall varied with the locus of the common letters.

5. Presumably this phenomenon can be obtained with other modes of stimulation, auditory, *e.g.*, with other than naming responses, with other kinds of similarity, and with wider degrees of dissimilarity than those employed. It is presumed that we are here dealing with a general principle, whose limitations are as yet undefined.

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